Development of Complex Curricula for Molecular Bionics and Infobionics Programs within a consortial* framework**

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**Molekuláris bionika és Infobionika Szakok tananyagának komplex fejlesztése konzorciumi keretben

***A projekt az Európai Unió támogatásával, az Európai Szociális Alap társfinanszírozásával valósul meg.

BASICS OF NEUROBIOLOGY

Neurobiológia alapjai

IONOTROPIC RECEPTORS

(Ionotrop receptorok)

ZSOLT LIPOSITS

TRANSMITTER RECEPTORS

WITH THE EXCEPTION OF STEROID SIGNALS AND UNCONVENTIONAL GAS TRANSMITTERS (NO, CO), REGULAR NEUROMESSENGERS CAN NOT DIFFUSE THROUGH THE CELL MEMBRANE

THEIR EFFECTS ARE MEDIATED BY RECEPTORS THAT ARE EMBEDDED INTO THE POST-SYNAPTIC MEMBRANE

RECEPTORS ARE COMPLEX PROTEINS THAT SHOW HIGH-AFFINITY BINDING FOR TRANSMITTER LIGANDS

LIGAND BINDING ALTERS THE CONFORMATION OF THE RECEPTOR THAT EVOKES POSTSYNAPTIC RESPONSES

THE RESPONSE DEPENDS ON THE AMOUNT OF THE TRANSMITTER, THE NUMBER AND STATE OF THE RECEPTORS

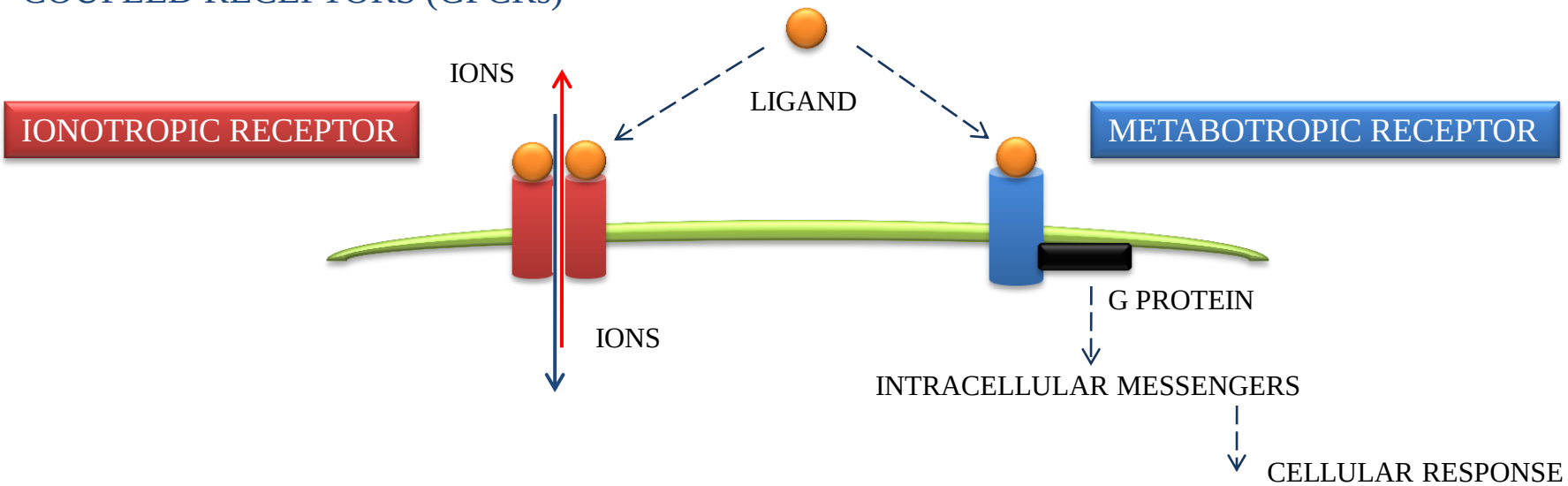
TRANSMITTER RECEPTORS BELONG TO TWO CATEGORIES:

- IONOTROPIC RECEPTORS
- METABOTROPIC RECEPTORS

TRANSMITTER RECEPTORS

IONOTROPIC RECEPTORS FORM PORES, SPECIFIC ION CHANNELS IN THE MEMBRANE THAT ALLOW THE PASSAGE OF IONS UPON ACTIVATION. THEY PERFORM AS LIGAND-GATED ION CHANNELS

METABOTROPIC RECEPTORS ARE COUPLED TO GTP-BINDING PROTEINS (G PROTEINS) VIA THEIR INTRACELLULAR DOMAINS. G PROTEIN ACTIVATION EVOKES SECONDARY RESPONSES IN THE CELL THAT ALTER THEIR METABOLISM. SYNONYM: G PROTEIN-COUPLED RECEPTORS (GPCRs)



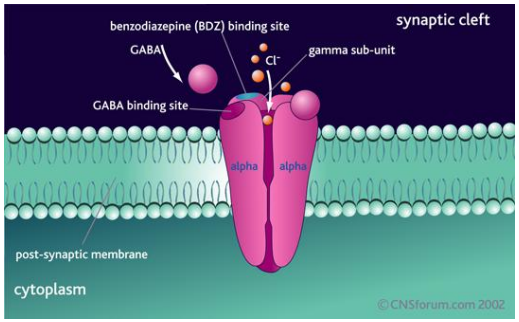
IONOTROPIC RECEPTORS

IONOTROPIC RECEPTORS BY GATING ION CHANNELS CONTRIBUTE TO FAST POST-SYNAPTIC RESPONSES

WITH REGARDS TO THE POSTSYNAPTIC EFFECT, THEY ARE EXCITATORY OR INHIBITORY IN NATURE

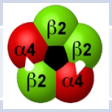
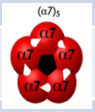
IONOTROPIC RECEPTOR FAMILIES COMPRISE THE FOLLOWING RECEPTORS:

- NICOTINIC ACETYLCHOLINE RECEPTOR (nAChR)
- GAMMA-AMINOBUTYRIC ACID A RECEPTOR (GABA-A)
- GLYCINE RECEPTOR
- SEROTONIN RECEPTOR (5-HT_3 SUBCLASS)
- GLUTAMATE RECEPTORS
  - NMDA RECEPTOR
  - AMPA RECEPTOR
  - KAINATE RECEPTOR



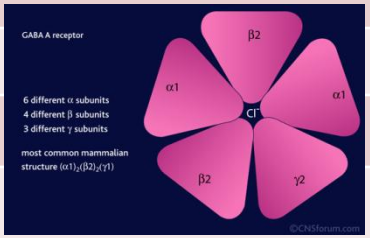
GABA A RECEPTOR

COURTESY OF LUNDBECK INSTITUTE, DENMARK

NICOTINIC ACETYLCHOLINE RECEPTOR	
ATTRIBUTE	DESCRIPTION
NAME	NICOTINIC ACETYLCHOLINE RECEPTOR
SUPERFAMILY	NICOTINIC ACETYLCHOLINE RECEPTOR
STRUCTURE	PENTAMERIC, HOMO- OR HETEROMERIC VARIANTS  
SUBUNITS	α1-10,β1-4, γ, δ, ε
EXPRESSION TYPES	MUSCLE HETEROMERIC $(\alpha1)_2\ \beta1\delta\varepsilon$, BRAIN HETEROMERIC $(\alpha4)_2\ (\beta2)_3$, BRAIN, GANGLION HOMOMERIC $(\alpha7)_5$, GANGLION HETEROMERIC $(\alpha3)_2\ (\beta4)_3$
LIGAND BINDING	EXTRACELLULAR DOMAIN NEAR TO N TERMINUS, AT SUBUNIT INTERFACES
BASIC ROLE(S)	OPENS PORES FOR SODIUM ION INFLOW AND POTASSIUM ION OUTFLOW, MUSCLE CONTRACTION, EPSP
AGONISTS	NICOTINE, CHOLINE, EPIBATIDINE
ANTAGONISTS	GANGLIONIC: HEXAMETHONIUM, MUSCLE: ATRACURIUM, SUCCINYLCHOLINE, BRAIN; 18-METHOXYCORONARIDINE
FUNCTIONAL ROLES	EXECUTION OF MOVEMENT AND AUTONOMIC FUNCTIONS, MODULATION OF CNS NETWORKS VIA PRE- AND POSTSYNAPTIC REGULATION
DISEASES	MYASTHENIA GRAVIS, CONGENITAL MYASTHENIC DISEASES, TOBACCO ADDICTION

GAMMA-AMINOBUTYRIC ACID A RECEPTOR (GABA-A)

ATTRIBUTE	DESCRIPTION
NAME	GAMMA-AMINOBUTYRIC ACID A RECEPTOR (GABA-A)
SUPERFAMILY	NICOTINIC ACETYLCHOLINE RECEPTOR
STRUCTURE	PENTAMERIC
SUBUNITS	α, β, γ, δ, ε, π, ψ, ISOFORMS: α1–6, β1–β3, γ1–γ3, ρ1–ρ3.
EXPRESSION TYPES	MORE THAN 100 SUBTYPES
LIGAND BINDING	GABA AGONIST AND ANTAGONIST BINDING SITE, BENZODIAZEPINE SITE, STEROID SITE, BARBITURATE SITE, PICROTOXIN SITE
BASIC ROLE(S)	REGULATES CHLORIDE CHANNEL, IPSP
AGONISTS	MUSCIMOL, BACLOFEN, ETHANOL, BARBITURATES, BENZODIAZEPINES
ANTAGONISTS	BICUCULINE
FUNCTIONAL ROLES	AGONISTS EXERT ANXIOLYTIC, ANTICONVULSANT, AMNESIC, SEDATIVE, HYPNOTIC AND MUSCLE RELAXANT EFFECTS
DISEASES	EPILEPSY, ANXIETY

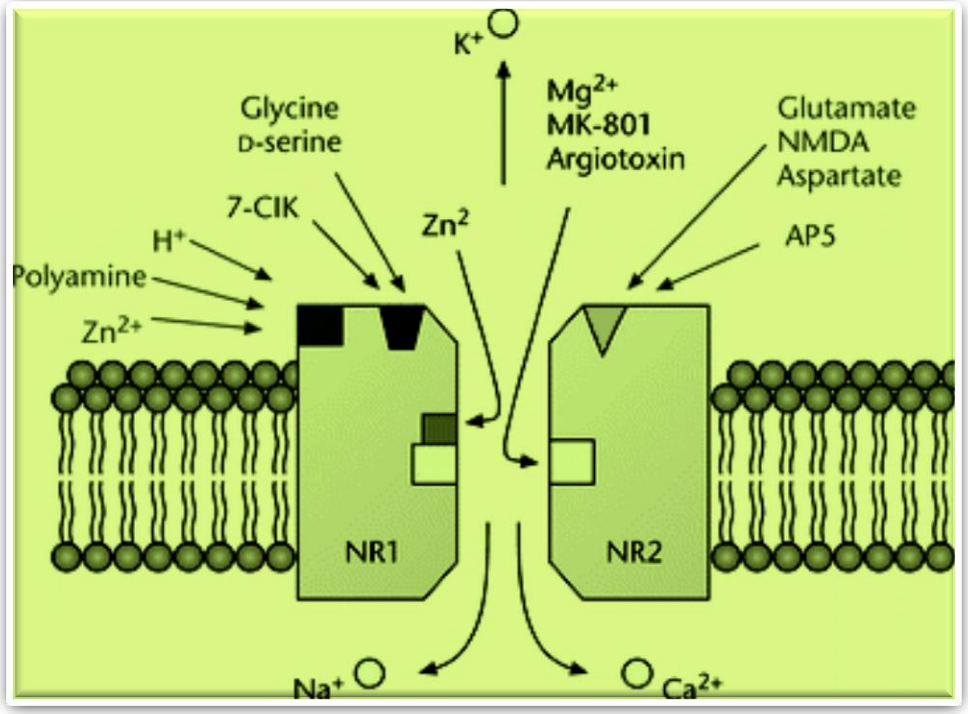


GLYCINE RECEPTOR	
ATTRIBUTE	DESCRIPTION
NAME	GLYCINE RECEPTOR
SUPERFAMILY	NICOTINIC ACETYLCHOLINE RECEPTOR
STRUCTURE	PENTAMERIC
SUBUNITS	5 SUBUNITS
EXPRESSION TYPES	$(\alpha 1)_3 \beta_2$ or $(\alpha 1)_4 \beta$
LIGAND BINDING	GABA AGONIST AND ANTAGONIST BINDING SITE, BENZODIAZEPINE SITE, STEROID SITE, BARBITURATE SITE, PICROTOXIN SITE
BASIC ROLE(S)	REGULATES CHLORIDE CHANNEL, IPSP
AGONISTS	SERINE, TAURINE,
ANTAGONISTS	STRYCHNINE, CAFFEINE
FUNCTIONAL ROLES	DOMINANT INHIBITORY NEUROTRANSMITTER IN THE SPINAL CORD AND BRAINSTEM
DISEASES	HYPEREKPLEXIA, STIFFNESS

SEROTONIN RECEPTOR (5-HT_3 SUBCLASS)	
ATTRIBUTE	DESCRIPTION
NAME	SEROTONIN RECEPTOR (5-HT_3 SUBCLASS)
SUPERFAMILY	NICOTINIC ACETYLCHOLINE RECEPTOR
STRUCTURE	PENTAMERIC, HOMOMERIC OR HETEROMERIC FORMATIONS
SUBUNITS	A-E
EXPRESSION TYPES	5-HT_{3A} AND 5-HT_{3B} SUBUNITS IN CNS
LIGAND BINDING	AT THE INTERFACE OF TWO ADJACENT SUBUNITS
BASIC ROLE(S)	OPENS PORES FOR SODIUM ION INFLOW AND POTASSIUM ION OUTFLOW, EPSP
AGONISTS	BENZYLPIPERAZINE, QUIPAZINE
ANTAGONISTS	CARBAZOLE, INDAZOLES, INDOLES
FUNCTIONAL ROLES	ROLE IN ADDICTION, ANXIETY, EMESIS, GI MOTILITY, NAUSEA
DISEASES	----------

GLUTAMATE RECEPTOR-NMDA TYPE	
ATTRIBUTE	DESCRIPTION
NAME	NMDA (N-methyl-D-aspartic acid) RECEPTOR
SUPERFAMILY	GLUTAMATE RECEPTOR
STRUCTURE	HETEROMERIC ASSEMBLIES MADE UP FROM NR1 SUBUNITS TOGETHER WITH AT LEAST ONE TYPE OF NR2 SUBUNIT
SUBUNITS	NR1, NR2, NR3 SUBFAMILIES
EXPRESSION TYPES	NR1: 8 ISOFORMS, NR2A-2D, NR3A-B (FOR SPLICE VARIANTS SEE TEXTBOOKS)
LIGANDS	IMPORTANT BINDING SITES FOR: NMDA, ASPARTATE, GLUTAMATE, GLYCINE, D-SERINE, POLYAMINE, $Zn2^{+}$, $Mg2^{+}$, H^{+}
BASIC ROLE(S)	NON SPECIFIC CATION CHANNEL ALLOWING CALCIUM, SODIUM AND POTASSIUM PASSAGE. FEATURES: LOW KINETICS, HIGH Ca^{2+} PERMEABILITY, VOLTAGE-DEPENDENT BLOCK BY $Mg2^{+}$, GLYCINE CO-ACTIVATOR, POLYAMINE ACTIVATION, $Zn2^{+}$ INHIBITION
AGONISTS	GLUTAMATE, ASPARTATE, GLYCINE, D-SERINE
ANTAGONISTS	AMANTADINE, KETAMINE, PHENCYCLIDINE
FUNCTIONAL ROLES	LONG TERM POTENTIATION, SYNAPTIC PLASTICITY
DISEASES	EXCITOTOXICITY

SCHEME OF BINDING SITES OF NMDA RECEPTOR



AMPA RECEPTOR	
ATTRIBUTE	DESCRIPTION
NAME	AMPA (α-AMINO-3-HYDROXY-5-METHYLISOXAZOLE-4-PROPIONIC ACID) RECEPTOR
SUPERFAMILY	GLUTAMATE RECEPTOR
STRUCTURE	HETEROTETRAMERIC
SUBUNITS	GluR1-GluR4
EXPRESSION TYPES	$(GluR1)_2(GluR2)_2$
LIGAND BINDING	EACH SUBUNIT HAS AN AGONIST BINDING SITE. THE RECEPTOR OPENS AND CLOSES FAST, GATED BY SODIUM
BASIC ROLE(S)	MEDIATE MOST EXCITATORY ACTIONS IN THE CNS, FAST KINETICS, LOW CALCIUM PERMEABILITY. EPSP
AGONISTS	AMPA, DOMOIC ACID
ANTAGONISTS	GYKI53655, KYNURENIC ACID
FUNCTIONAL ROLES	SYNAPTIC TRANSMISSION, SYNAPTIC PLASTICITY
DISEASES	MOTOR NEURON DISEASE (AMYOTROPHIC LATERAL SCLEROSIS; ALS

KAINATE RECEPTOR	
ATTRIBUTE	DESCRIPTION
NAME	KAINATE RECEPTOR
SUPERFAMILY	GLUTAMATE RECEPTOR
STRUCTURE	TETRAMERIC
SUBUNITS	GluR5-GluR7, KA1-KA2
EXPRESSION TYPES	SUBUNITS FORM HOMO- AND HETERODIMERS
LIGAND BINDING	POCKET AT GluR6
BASIC ROLE(S)	EXCITATORY AT POSTSYNAPTIC SITES, INHIBITORY AT PRESYNAPTIC LOCI. PORES ARE PERMEABLE FOR SODIUM AND POTASSIUM. KEPT OPEN SHORTER THAN AMPA RECEPTOR PORES
AGONISTS	SYM 2081, KAINIC ACID, DOMOIC ACID
ANTAGONISTS	NS102, KYNURENIC ACID
FUNCTIONAL ROLES	FUNCTION-DEPENDENT SYNAPTIC PLASTICITY
DISEASES	EPILEPSY